THE STAR POCKET-BOOK

OR

HOW TO FIND YOUR WAY AT NIGHT BY THE STARS

A SIMPLE MANUAL FOR THE USE OF SOLDIERS, TRAVELLERS, AND OTHER LANDSMEN

BY

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WITH A FOREWORD BY

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FOREWORD

It gives me much pleasure to commend this little book to those who have to find their way at night by the help of the stars. The diagrams are excellent, and the tables are simple and clear.

But a book like this will also make an appeal to a wider circle. Every man, woman, and child ought to be able to distinguish the principal stars. No one can have an excuse for not being able to do so when so helpful a celestial guide as this little book is available.

ROBERT S. BALL.

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THE STAR POCKET-BOOK

INTRODUCTORY

I HAPPENED some time ago to lecture, to a number of Army officers going through a course of Intelligence work, on "The Use of the Stars in Night Marches." They appeared to find my notes of interest and service, and this suggested to me that perhaps a small pocket-book devoted to a practical consideration of the matter might be found useful by soldiers; possibly, too, by other landsmen who are interested in the stars, or may have occasion to walk or ride by night through unfamiliar country. Furthermore, the fact that the results arrived at are obtained rather by observation and practice than by mathematical calculations (which are here of the simplest) should render the work well adapted to the needs and the tastes of the Boy Scouts.

The first question, naturally, is: "What can a

landsman get by the use of the stars?" To the seaman, of course, they may be of great assistance; and a good observer under favourable conditions is able by their aid to convert his general idea of the position of his ship into one that is not more than a mile or so incorrect. In fact, given fine nights, he could pick his way round the world though he never saw the sun. But it by no means follows that the traveller by night on land will be able to, or indeed wants to, make the same use of the stars. For consider; the navigator has at his command, to assist him, chronometer, charts, sextant, nautical almanac and figure tables: the night-marcher *may* have all these, and an artificial horizon instrument as well, but except on a scientific expedition he is very unlikely to. Again, the former takes and works out his observations without any waste of time to the ship and with light and comfort; the latter may have to stop to do so and thus lose time, and the conditions under which he is likely to be working tend to introduce errors. The one, traversing immense tracts of ocean, has a result near enough for his purpose; but to the other, working on a smaller scale, the inevitable margin

of error might make all the difference between success and failure.

Position, then, to the landsman, is (even if desirable) quite unfeasible; what the stars give him is *direction*. And first let us be quite clear what we mean when we speak of the stars giving "direction." Not of course that they act as a kind of wayside finger-post pointing "X—— 12 miles," and so forth: this is more than can reasonably be expected; and if a wanderer is so completely lost that he has no notion whether his home lies north or south or east or west, all the star-lore in the world will do no more for him than enable him to choose some direction and hold to it. But this it will do. It will, in the simplest and best case, give us the N. and S. points, and we must make what use we can of that knowledge. Perhaps it has been possible to work out the bearing of destination from starting-point to be (say) N. 65° E. We lay off this angle on a piece of paper or cardboard, and pointing the one line at the ascertained N. point proceed to march along the other.

The best direction to be obtained is this N. and S. line, but it is not the only possible one. It

may be possible and convenient to do what is known as "marching on a star." That is to say a certain star is selected beforehand, and its bearings at given intervals, say of half-an-hour, are worked out in advance and noted down. If then the bearing of our destination is known we have only to keep the right direction angles with the star at the right times to be following the line we require. The ways in which the necessary data can be obtained are clearly set forth in Major Tilney's "Rapid Night Marching Made Easy," and for a predetermined and properly planned and equipped night march this plan is satisfactory enough.

But for the preliminary work of finding these changing star-bearings a Nautical or Whitaker's Almanac[1] and Bearing Tables (or substitute) are requisite; or, better still, a Reeve's Astronomical Compass. And such things will not always be available, while it may yet be possible to find the N. and S. direction; and this with very little

[1] This pocket-book will serve in place of an Almanac. To use the Bearing Tables we require two data, the Star's Hour Angle and Declination. The first is found with sufficient accuracy by Table X, the second is given in Table Y.

help, or none at all, from external appliances, by one's own memory and observation, things one always (presumably) has about one.

Once the N. and S. line is known a regular worked-out night march can proceed, as before, on its proper angle. But further, a strayed detachment, a unit lost *en route*, or a bewildered night-walking civilian who simply has this pocket-book with him, or far better, just remembers some of its simple points, has an excellent chance under any skies of being able to say, "There lies the North," and so proceeding in some favourable direction; and this even on nights when the stars seen are few or infrequent.

The problem, therefore, that will be considered here is, "How to find the N. and S. line at night by the stars."

PRELIMINARY

In the "Field Service Pocket-Book" and elsewhere one way of finding the Pole Star, that is the N. point, is given; also a rule for obtaining the South Pole—the one by means of the Great Bear, the other by means of the Southern Cross. If then in any latitude one or the other of these constellations were always well visible at night we should have all we need; no other stars need be known, no data or tables or instruments would be required.

But the Pole Star is of little use south of Lat. 10° N., and the Great Bear and the Cross, even in latitudes where they are visible, are not necessarily visible all the year round. Besides, clouds, or moonlight, or wooded or hilly country may obscure just that part of the heavens that we want. It is better to be less dependent on one or two particular markers. That is, we must know more stars.

The first thing necessary, then, is to learn how to identify as many stars as are desirable for our use.

TO IDENTIFY THE CHIEF STARS

It is much better to learn to know the stars than to be dependent on charts showing their positions relative to the Poles. Nor is this really a difficult matter at all; most of the bright stars are easily found and distinguished from one another. A number of Star Plans follow, in what appears to be a convenient order, namely, starting with the Great Bear and leading on in all directions by means of the stars directly obtainable from it. The ways given here, mostly well known, are simple, and all tested by actual use. Of course memory, practice, and patience are required; for constellations and stars look different in different positions; but the relative positions remain the same, the stars are checks on one another, and gradually it becomes a simple matter to pick them out even when the best pointers are not to be seen.

Attention is called to the following points:—

1. Only stars considered necessary for use, or serviceable as pointers to the necessary ones, are marked in the plans. Thus the welter of fine

stars in the Ship and the Centaur and some others, particularly in the South Hemisphere, which are not easily identified, are omitted altogether.

2. As the sky is a sphere, when large tracts of it are plotted on a plane stars far apart may not always look in plans to have the relative positions ascribed to them.

3. Again, when we speak of three stars being "in line," we really mean on the same circle (the observer being at the centre), and in taking the "line" between two stars the eye must allow for this.

4. Finally, in estimating distances between stars seen in the sky, as we sometimes require to do, remember that distances appear greater low down in the sky than they do well overhead.

NOTE ON THE NOMENCLATURE OF THE STARS

The stars are divided up into groups known as Constellations. These are given names, somewhat fanciful as a rule, from supposed figures formed by the stars in them; such as Great Bear, Lion, Eagle, Scorpion (a real likeness), Ship, and so on.

In any constellation the stars are lettered α (alpha), β (beta), γ (gamma), δ (delta), ϵ (epsilon), &c., in order of apparent magnitude as a rule. Thus the best star in AQUILA, the Eagle, is α AQUILAE (the alpha star of the constellation AQUILA); so α CYGNI, α URSAE MAJORIS, &c. But nearly all the brightest stars have their proper individual names as well; thus α AQUILAE is Altair, α CYGNI is Deneb, and so on.

The brightest stars are always spoken of by these individual names, but some stars of less importance are referred to sometimes by their proper, sometimes by their family names: thus Hamel or α ARIETIS, Alpherat or α ANDROMEDAE, Markab or α PEGASI.

To avoid confusion we shall always use small capital letters for the Latin CONSTELLATION names, and ordinary type for the individual star names.

Tables (Tables I. and II.) giving the names of stars follow.

TABLE I

The Great Stars in descending order of Magnitude.

Proper Name of Star.	Star Plan found in	Constellation Name of Star.	English Name of Constellation.	Magnitude of Star.
	No.			
Sirius . .	9	α CANIS MAJORIS	The Great Dog	−1·4
Canopus * .	11	α ARGUS	The Ship, Argo	−1·0
Vega . . .	4	α LYRAE	The Lyre	0·1
Capella * .	6·8	α AURIGAE	The Charioteer	0·2
Arcturus .	3	α BOÖTIS	The Herdsman	0·3
Rigel * . .	9	β ORIONIS	The Hunter, Orion	0·3
Procyon * .	9	α CANIS MINORIS	The Little Dog	0·5
Achernar .	13	α ERIDANI	The River Eridanus	0·5
.. ..	12	*β CENTAURI	The Centaur	0·8
Altair . .	4	α AQUILAE	The Eagle	0·9
.. ..	12	α CENTAURI	.. ..	1·0
.. ..	12	*α CRUCIS	The Southern Cross	1·0
Betelguese *	9	α ORIONIS	.. ..	1·0
Aldebaran .	8	α TAURI	The Bull	1·1
Pollux * . .	6·	β GERMINORUM	The Heavenly Twins	1·2
Spica * . .	3	α VIRGINIS	The Virgin	1·2
Deneb * . .	4	α CYGNI	The Swan	1·3
Fomalhaut *	8	α PISCIS AUSTRALIS	The Southern Fish	1·3
Antares . .	5	α SCORPII	The Scorpion	1·3
Regulus . .	2	α LEONIS	The Lion	1·3
.. ..	12	*β CRUCIS	.. ..	1·5
.. ..	12	*γ CRUCIS	.. ..	1·6
Bellatrix .	9	γ ORIONIS	.. ..	1·7
Mirfak . .	8	α PERSEI	Perseus	1·9
Castor . .	6·9	α GERMINORUM	.. ..	2·0
Polaris . .	1·7	α URSAE MINORIS	The Little Bear	2·1
Hamel * . .	8	α ARIETIS	The Ram	2·2
Denebola * .	2	β LEONIS	.. ..	2·2
Alphard .	9·10	α HYDRAE	The Hydra	2·2

Stars marked thus * are simul-transit and of especial importance as explained later.

Note.—The unit of brightness adopted is designated 1·0, so that Rigel 0·3 is seven-tenths of a magnitude greater than Betelguese, a unit star. Canopus −1·0 is 2·0 whole magnitudes brighter than the unit, and so on.

TABLE II

Lesser Stars of importance, in their Constellations.

English Name of Constellation.	Star Plan found in	Constellation Name of Star.	Proper Name of Star.	Magnitude of Star.
	No.			
The Great Bear . . .	1	*α URSAE MAJORIS	Dubhe	2·0
		*β ,, ,,	Merak	2·4
		*γ ,, ,,	Phecda	2·5
		δ ,, ,,	Megrez	3·4
		ε ,, ,,	Alioh	1·6
		*ζ ,, ,,	Mizar	2·1
		*η ,, ,,	Benetnasch	1·9
The Chair of Cassiopeia	7	α CASSIOPEIAE	Schedar	2·2
		*β ,,	Caph	2·4
		*γ ,,	.. ..	2·3
		*δ ,,	.. ..	2·8
		*ε ,,	.. ..	3·5
Andromeda	8	*α ANDROMEDAE	Alpherat	2·1
		*β ,,	Mirach	2·4
		*γ ,,	Almach	2·2
The Winged Horse, Pegasus	8	*α PEGASI	Markab	2·6
		*β ,,	Scheat	2·2
		γ ,,	Algenib	2·9
The Swan	4	γ CYGNI	.. ..	2·3
		*δ ,,	.. ..	3·0
		*ε ,,	.. ..	2·6
The Great Dog	9	*β CANIS MAJORIS	Mirzam	2·0
The Charioteer	6·8	*β AURIGAE	Menkalinan	2·1
The Centaur	12	*γ CENTAURI	.. ..	2·4

Stars marked thus * are simul-transit stars and of especial importance.
The stars tabulated above are usually known by their constellation names; the proper names added here need not be remembered.

NOTE ON THE PLANETS

The Planets, being, like the Earth, satellites of the Sun revolving round it, change their apparent positions in the sky. It is, therefore, very inadvisable to use them for our purpose, and care must be taken not to mistake one of them for one of the bright stars.

The normally visible planets are four: Venus, Jupiter, Mars, and Saturn.

Of these it may be said in general that their light is different from and distinguishable from that of the stars. For the planets shine only with light reflected from the sun, that is, dead calm light like that of the moon; they do not twinkle, scintillate, and throb with living light as stars of the same brightness are seen to do.

In particular: Venus is seen about sunset or dawn, and is so bright that it is hardly possible to mistake it for anything else. Jupiter is also bright, but, being often found in the neighbourhood of the bright stars about Orion, is sometimes carelessly mistaken for one of them, probably

Sirius. Mars is less bright and of a very red colour. Saturn is less bright again, and is the easiest to mistake for a star, perhaps for Fomalhaut, between which and the Square of PEGASUS it is commonly found.

NOTE ON THE STAR PLANS TO FOLLOW

The opinion is often expressed that star plans are usually too complicated. The stars of a constellation are often linked up by dotted lines irrespective of the consideration whether they actually appear to be so linked in the sky or not; and these lines only serve to confuse the learner. He does not gather from the plan the picture he sees in the heavens. For example, the seven stars of the Great Bear are justly linked up, for to any one who looks at the sky they appear as integrally connected. But on the other hand there is no real connection between, say, Regulus and Denebola in the Lion (Plan 2); the eye does not see them linked, and does not want to.

Accordingly, as these star plans are purely practical, and there is no need for the observer, as a rule, to follow out the course of a constellation, these linking dotted lines have been sparingly used, only in cases where, as in the **W** of CASSIOPEIA (Plan 7), and the **T** of the Swan (Plan 4), there seems to be an actual visual connection, or

where, as in the sweep of the Great Bear's tail to Arcturus and Spica (Plan 3), or the linking-up of the stars of PERSEUS and ANDROMEDA (Plan 8), it seems advisable for practical purposes to learn to see them as so connected.

The distances between stars are fairly correct for each plan; but the scale used is clearly not the same in all, but as convenient.

STAR PLANS

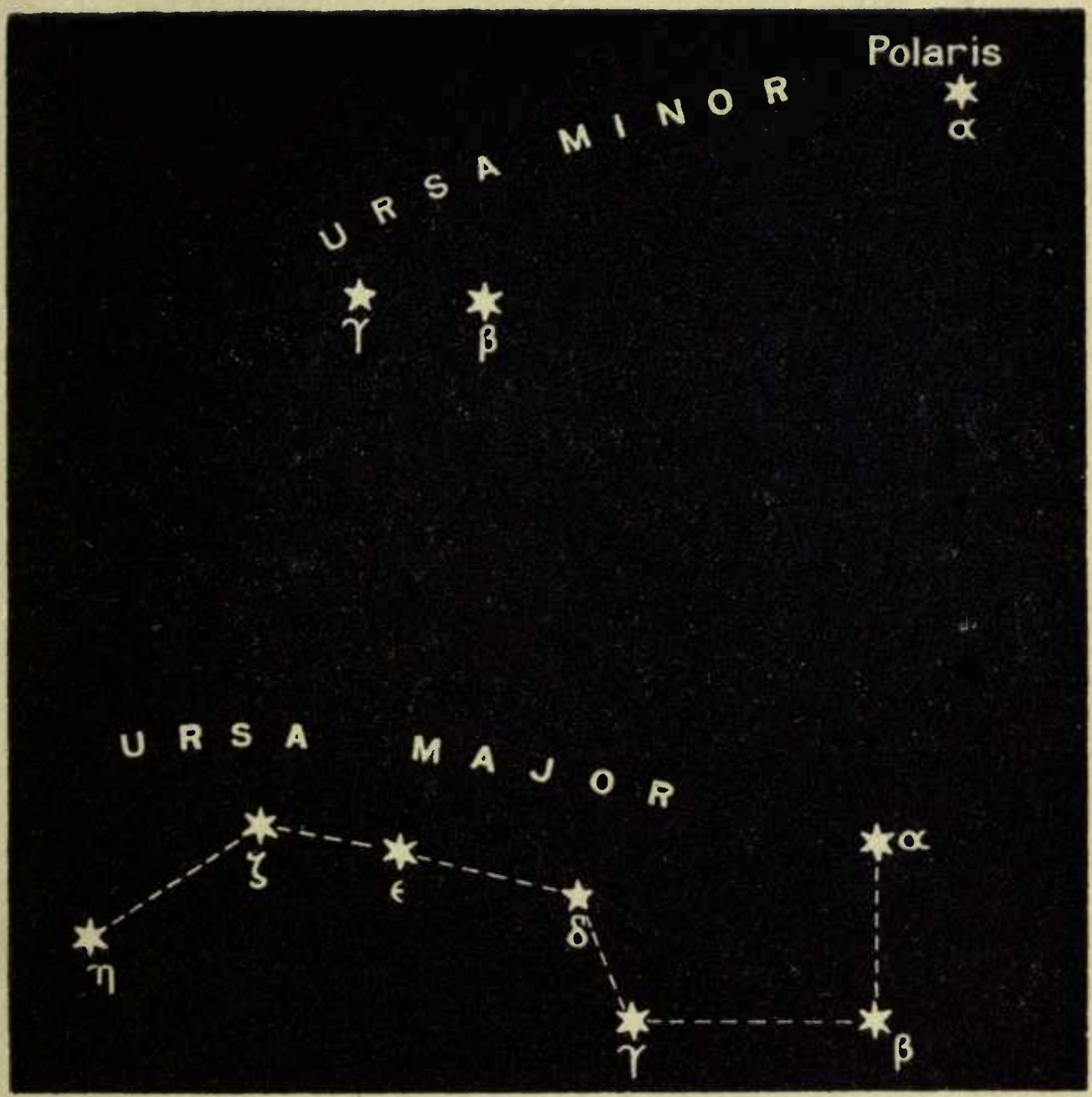
1. The Great Bear

The Great Bear is the most important of the Constellations. It is at once the easiest to distinguish, the easiest to find the North Pole by, and the best starting-point from which to learn the other stars.

URSA MAJOR is the ancient name; from its well-known form, as shown in the figure, it is often known in England as the "Plough," or "Charles' Wain." There are other names as well. We have in it the following very useful pointers to important stars:—

$\beta\alpha$	points	towards	Polaris
$\gamma\delta$	,,	,,	Deneb
$\beta\delta$	,,	,,	Vega
$\beta\gamma$	,,	,,	Arcturus
$\alpha\gamma$	,,	,,	Spica
$\alpha\beta$	,,	,,	Denebola
$\delta\gamma$	,,	,,	Regulus
$\delta\beta$	,,	,,	Castor and Pollux
$\gamma\beta$	,,	,,	Aldebaran
$\delta\alpha$	,,	,,	Capella

PLAN 1



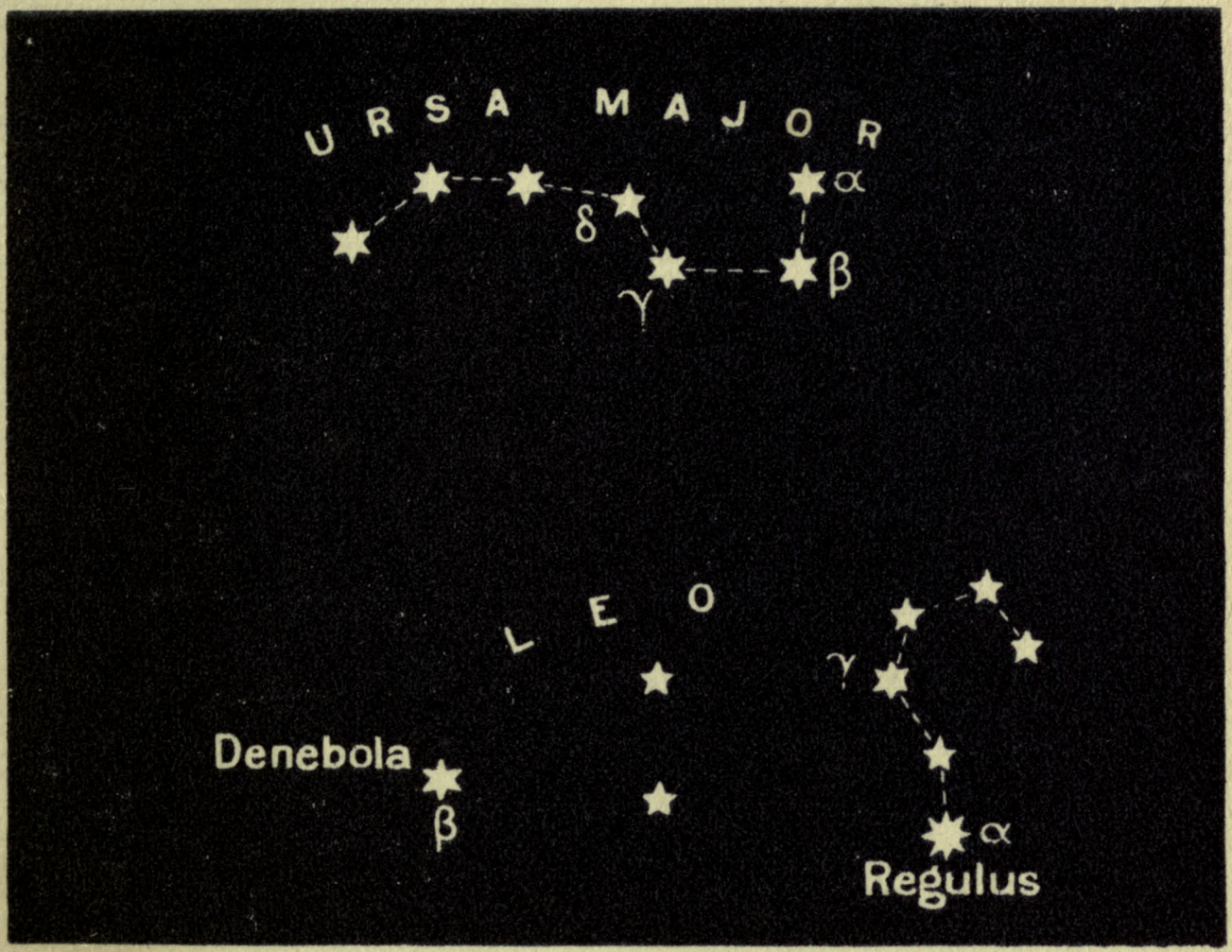
B

2. Regulus and the Lion

Regulus is easily distinguished by the sickle formed by six stars of LEO, Regulus being in the handle.

Denebola is some distance away, as in the figure, and rather to the left of the line from $\alpha\beta$ URSAE MAJORIS.

PLAN 2



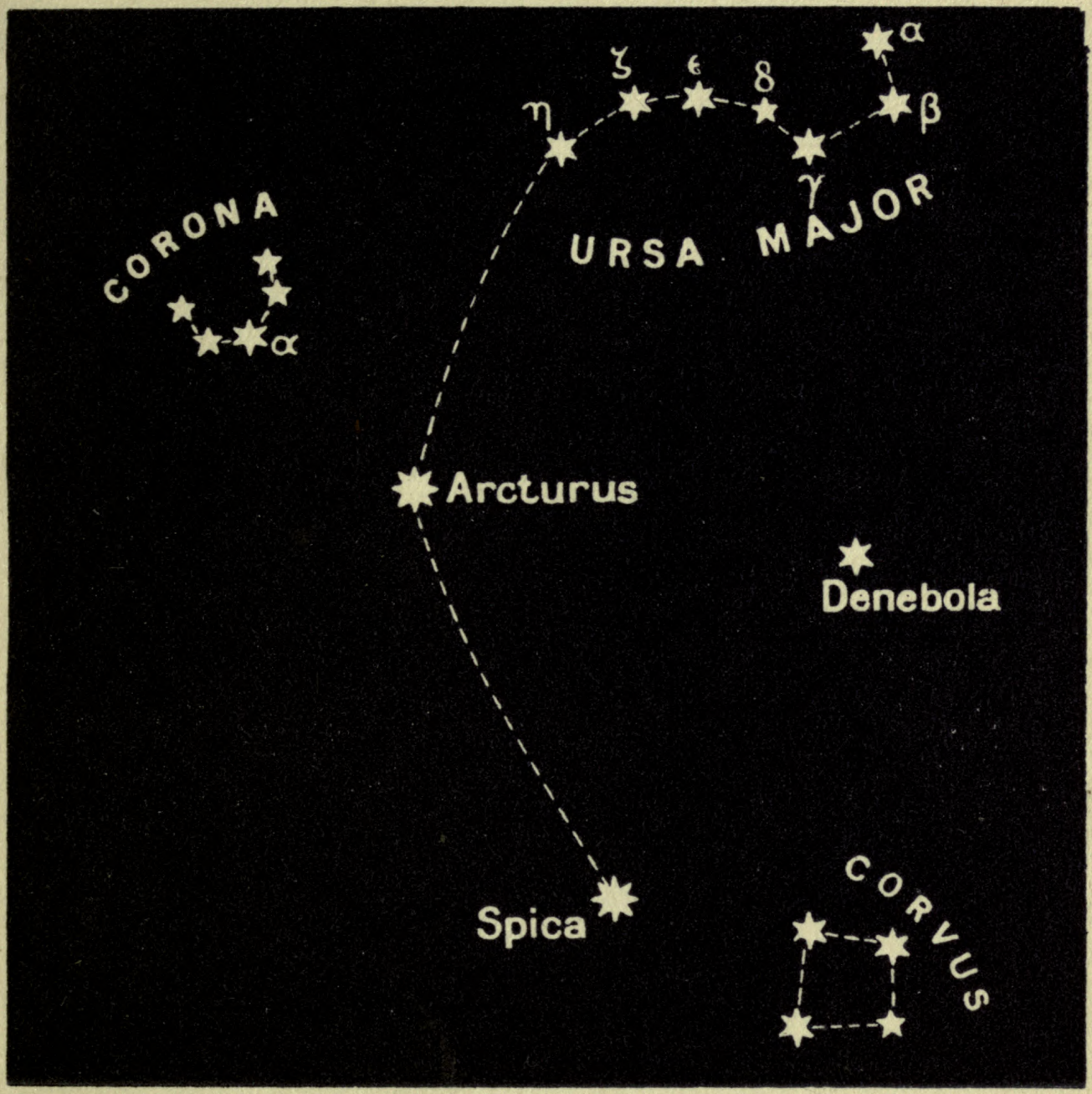
3. Arcturus and Spica

Arcturus and Spica are reached by following on the sweep of the tail of the Bear.

They have each a good marker not far away, namely, Arcturus has the semicircle of stars called the Northern Crown, and Spica has the sail-shaped quadrilateral in CORVUS.

Denebola, Arcturus, and Spica form an equilateral triangle.

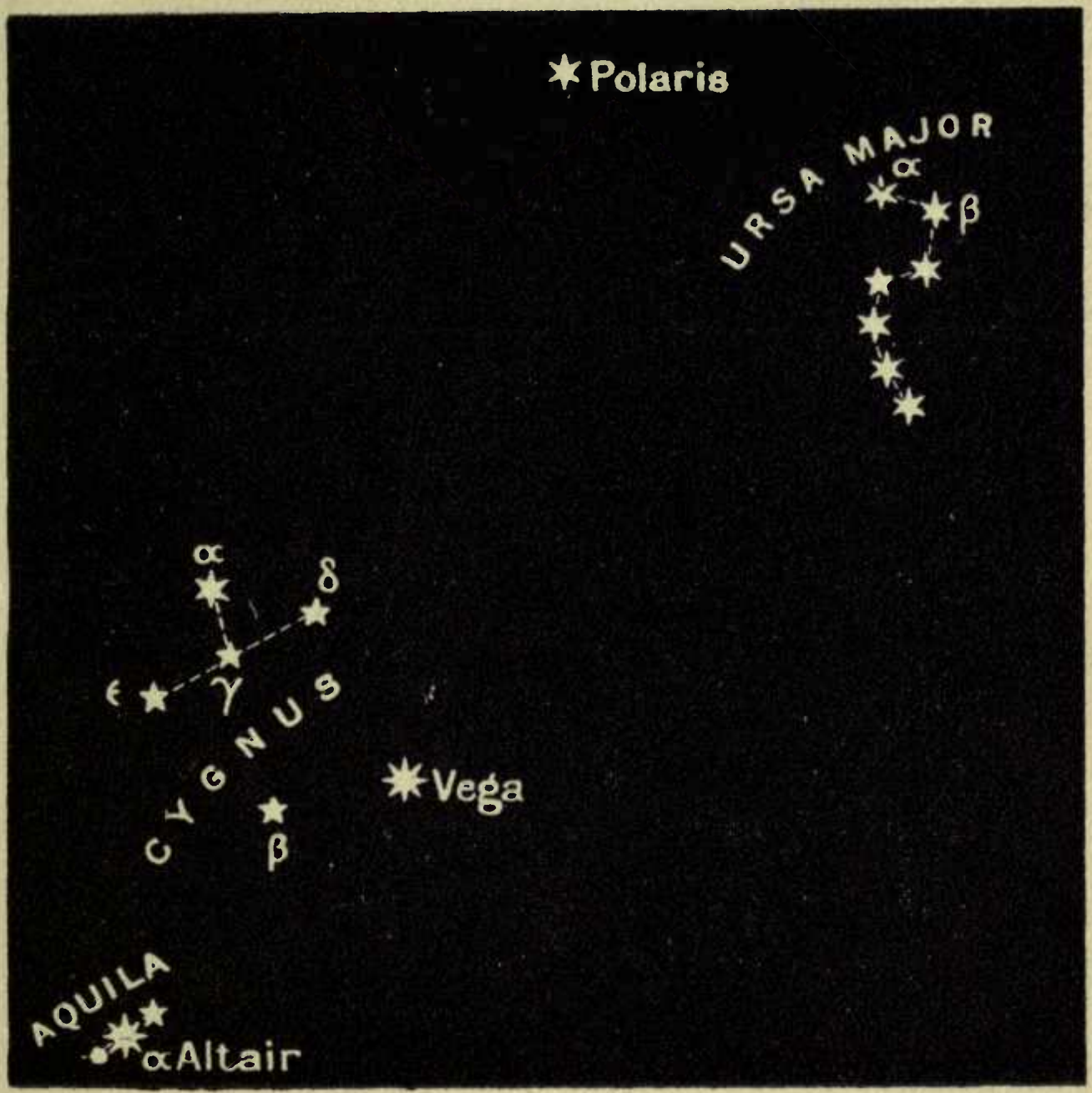
PLAN 3


CORONA
α
URSA MAJOR
ζ
ε
δ
η
α
β
γ
Arcturus
Denebola
Spica
CORVUS

4. The Lyre, Swan, and Eagle

Altair is the middle one of three stars in a straight line pointing to Vega. Deneb is in a foot of a T formed by four stars in CYGNUS. Vega has a tail of very small stars near it, but nothing at all bright.

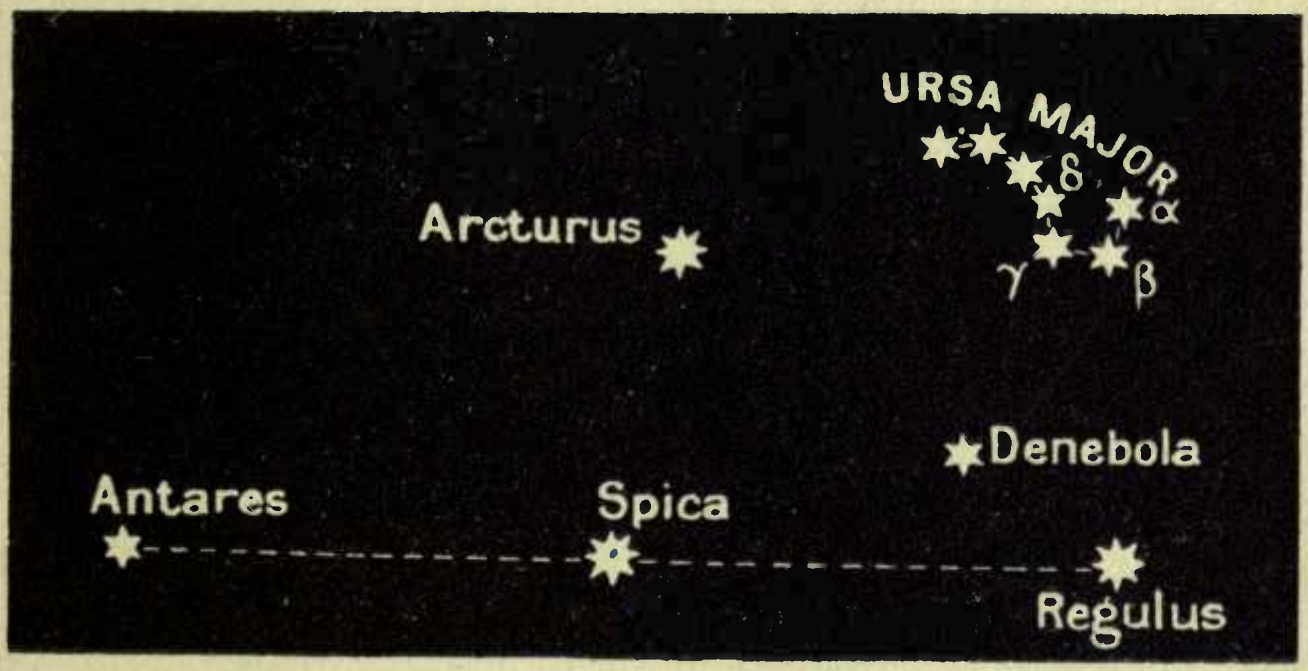
PLAN 4



5a. Antares and the Scorpion

Antares, Spica, and Regulus are in a straight line and at equal distances, as in the figure.

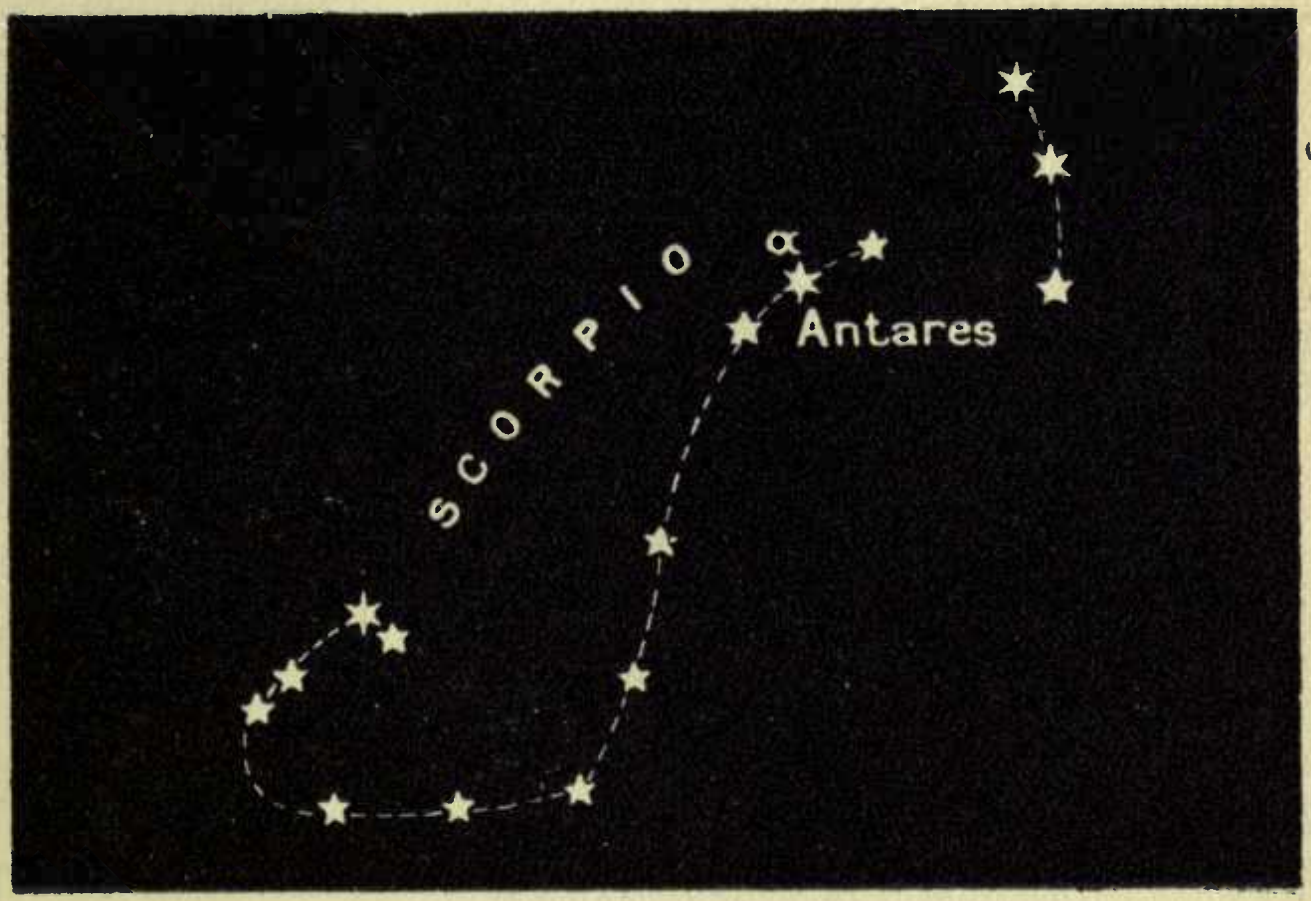
PLAN 5a



5b. Antares and the Scorpion

The form of the Scorpion is as above. Antares is the middle one of three stars, but the fact that they form a slightly curved line should prevent its being mistaken for Altair. Also there are three other stars in a curved line close to, as in the figure.

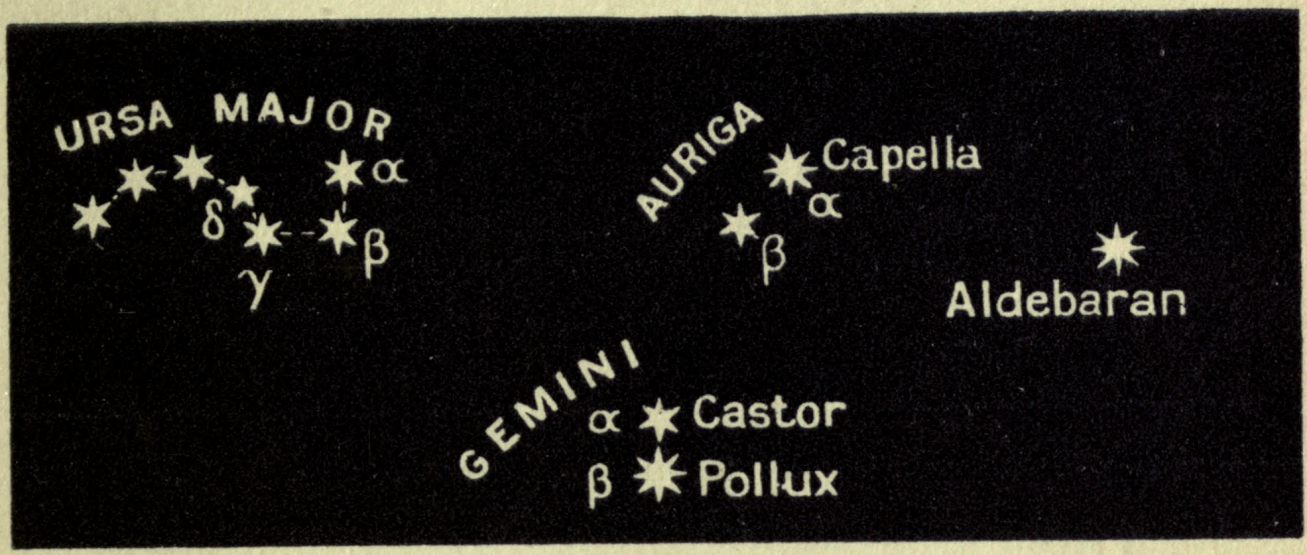
PLAN 5b



6. Capella and the Twins

Care must be taken to distinguish between the two pairs of stars, Capella and β AURIGAE, and Castor and Pollux. The direction lines from the Great Bear, and others to follow later, will help to do this: it is useful to remember that the former pair are rather farther apart, and there is more difference in the brightness of the two stars composing it.

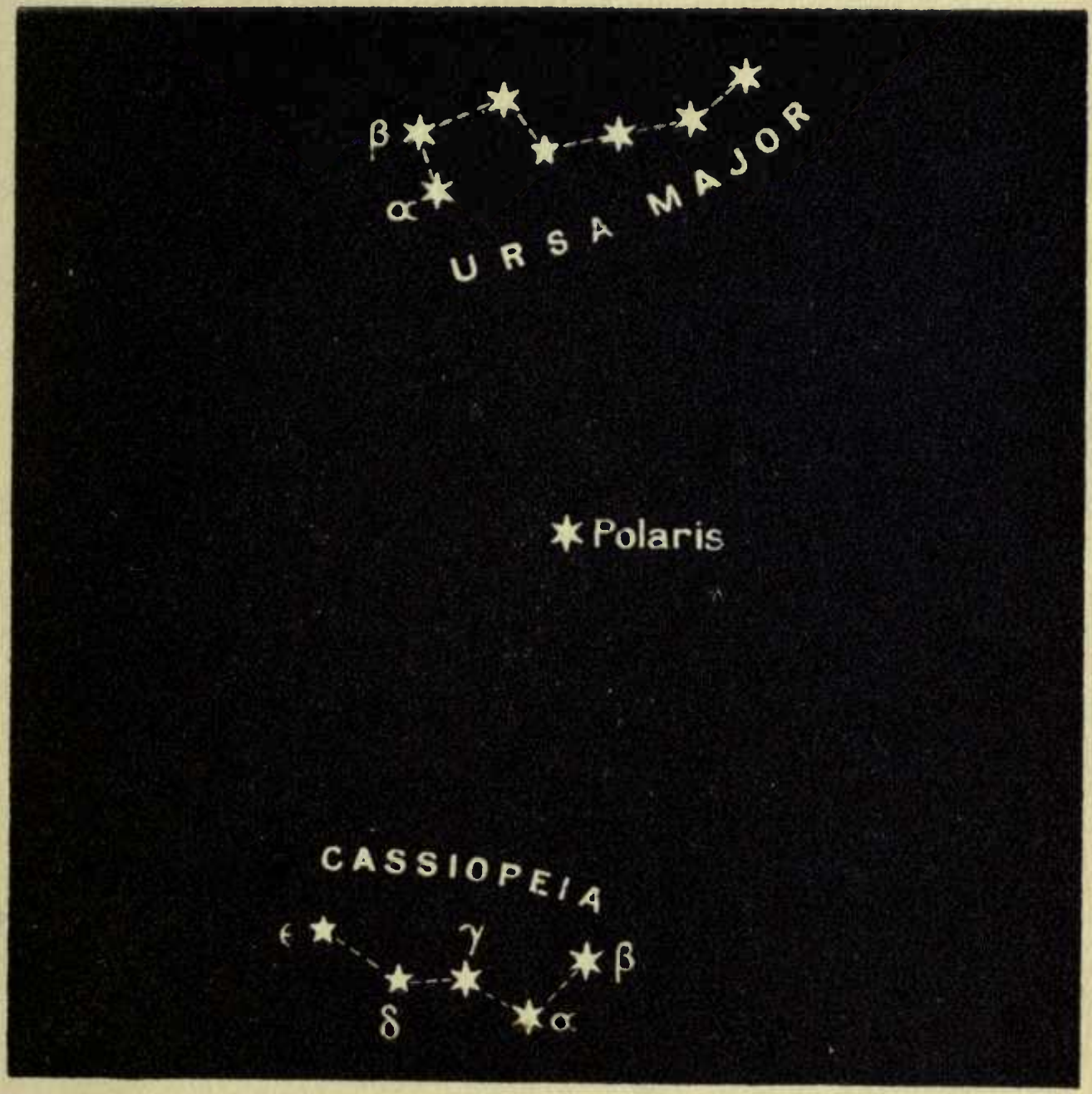
PLAN 6


URSA MAJOR
α
β
γ
δ
AURIGA
Capella
α
β
Aldebaran
GEMINI
α Castor
β Pollux

7. CASSIOPEIA

This is a very important constellation, as it is often seen when the Great Bear is invisible. It lies almost opposite the Great Bear on the other side of the Pole, and about the same distance from it. Its form is that of a **W**.

PLAN 7



8. PERSEUS, ANDROMEDA, and the Square of PEGASUS

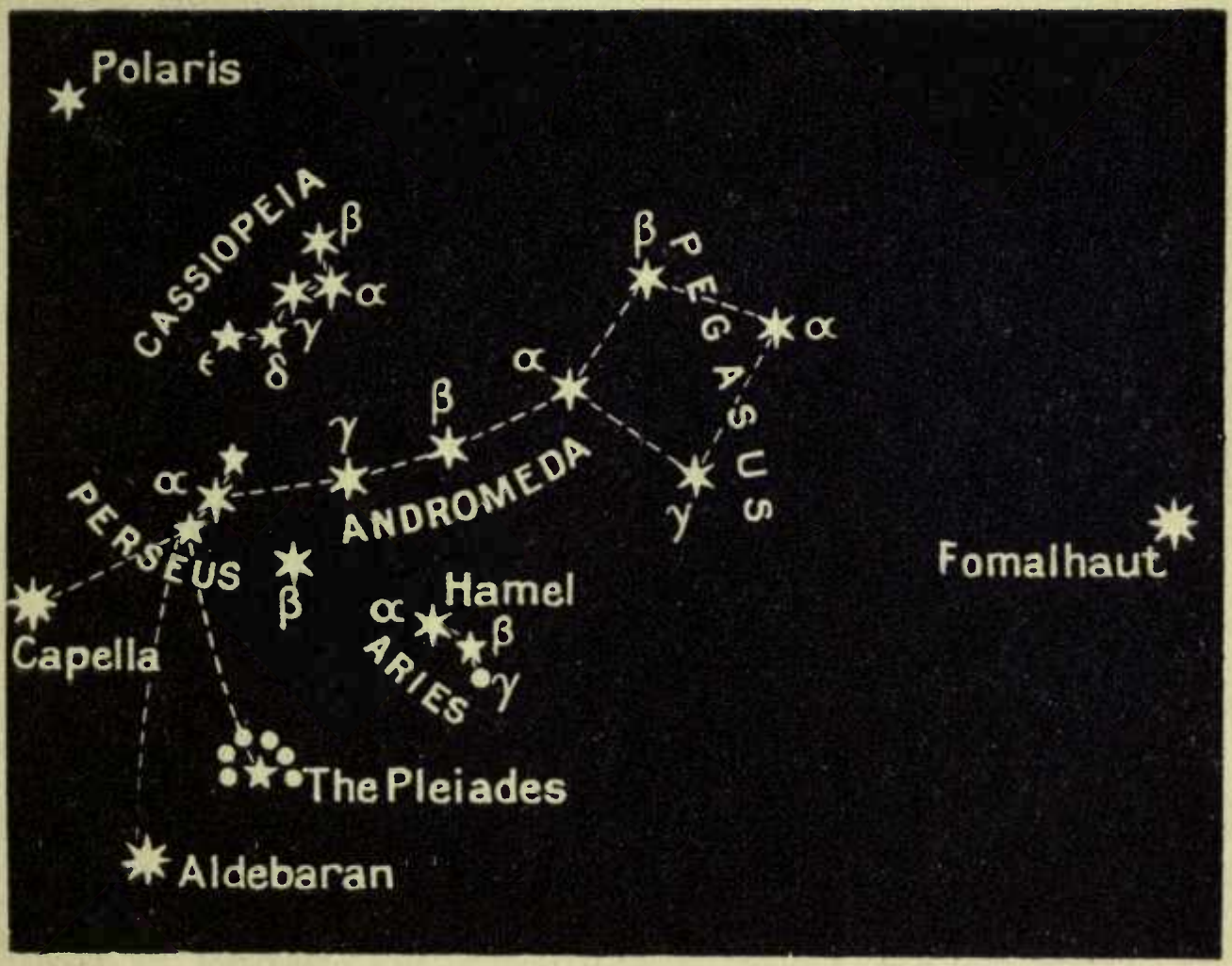
$\gamma\delta$ CASSIOPEIAE points to PERSEUS, PERSEUS direct to Aldebaran as in the figure, and away on each side to Capella and the well-known star cluster, the Pleiades.

α PERSEI and the three stars γ, β, α ANDROMEDAE lie at equal distances in a slightly curving line leading to the Square of Pegasus, of which α ANDROMEDAE is one corner.

β, α PEGASI points to the lonely bright star Fomalhaut.

α, β PERSEI points in the direction of Hamel, which is easily identified by the two smaller stars close to it.

PLAN 8

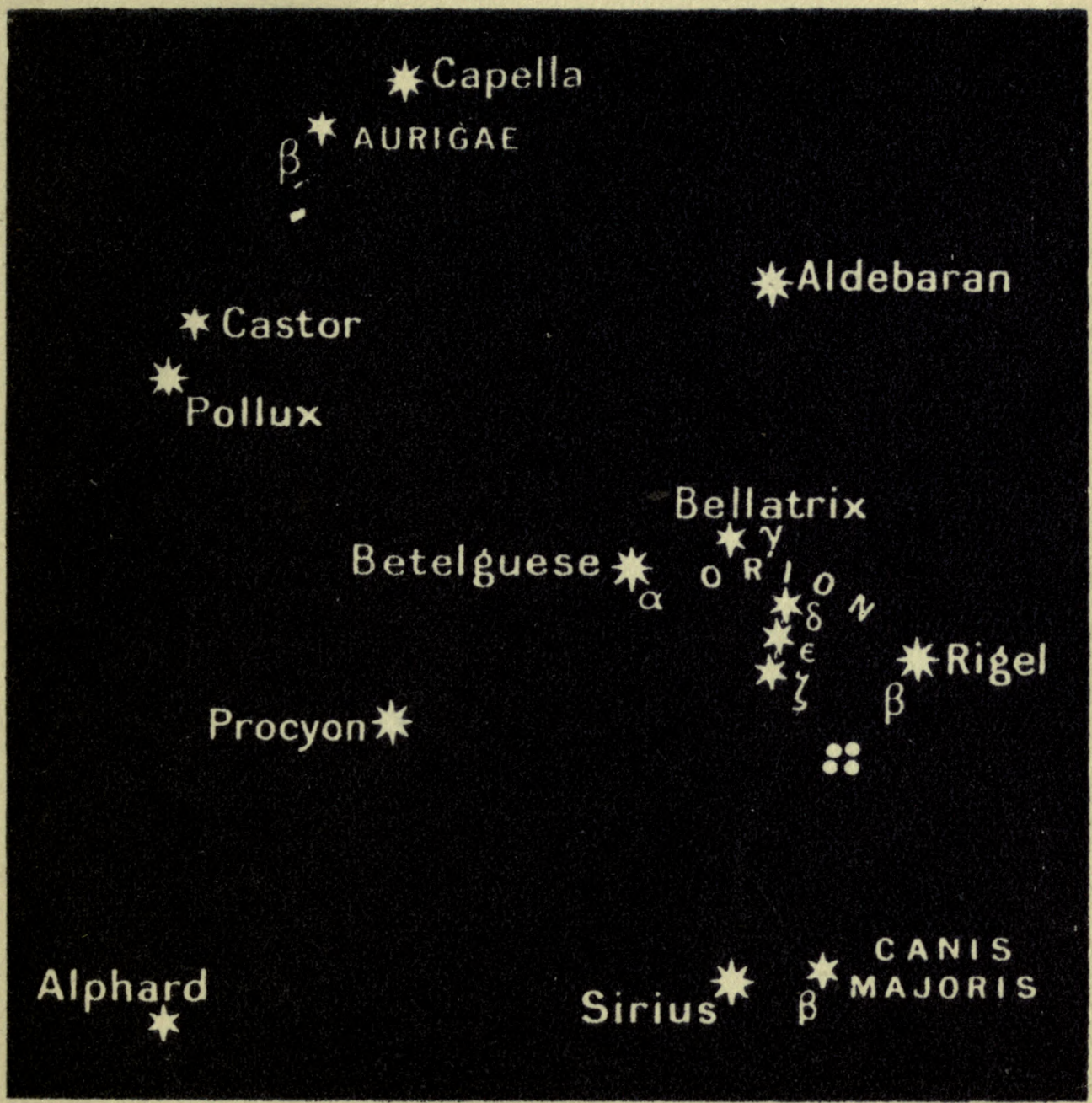

Polaris
CASSIOPEIA
β
α
γ
ε
δ
β
PEGASUS
α
α
β
γ
α
PERSEUS
ANDROMEDA
γ
Fomalhaut
β
Hamel
α
β
γ
ARIES
Capella
The Pleiades
Aldebaran

9. ORION with Sirius, Procyon, Aldebaran, &c.

The Belt of ORION (*i.e.* δεζ ORIONIS) points directly to Sirius and Aldebaran at equal distances from it, one each way. Betelguese and Rigel are at equal distances from the Belt, one each side of it. The line through Rigel and Betelguese comes to Castor and Pollux. Procyon is nearly midway between Sirius and Pollux, and a circle with Procyon as centre will roughly pass through Sirius, Alphard, and Pollux.

A larger circle with Procyon as centre will roughly pass through Rigel, Aldebaran, β AURIGAE, and Regulus.

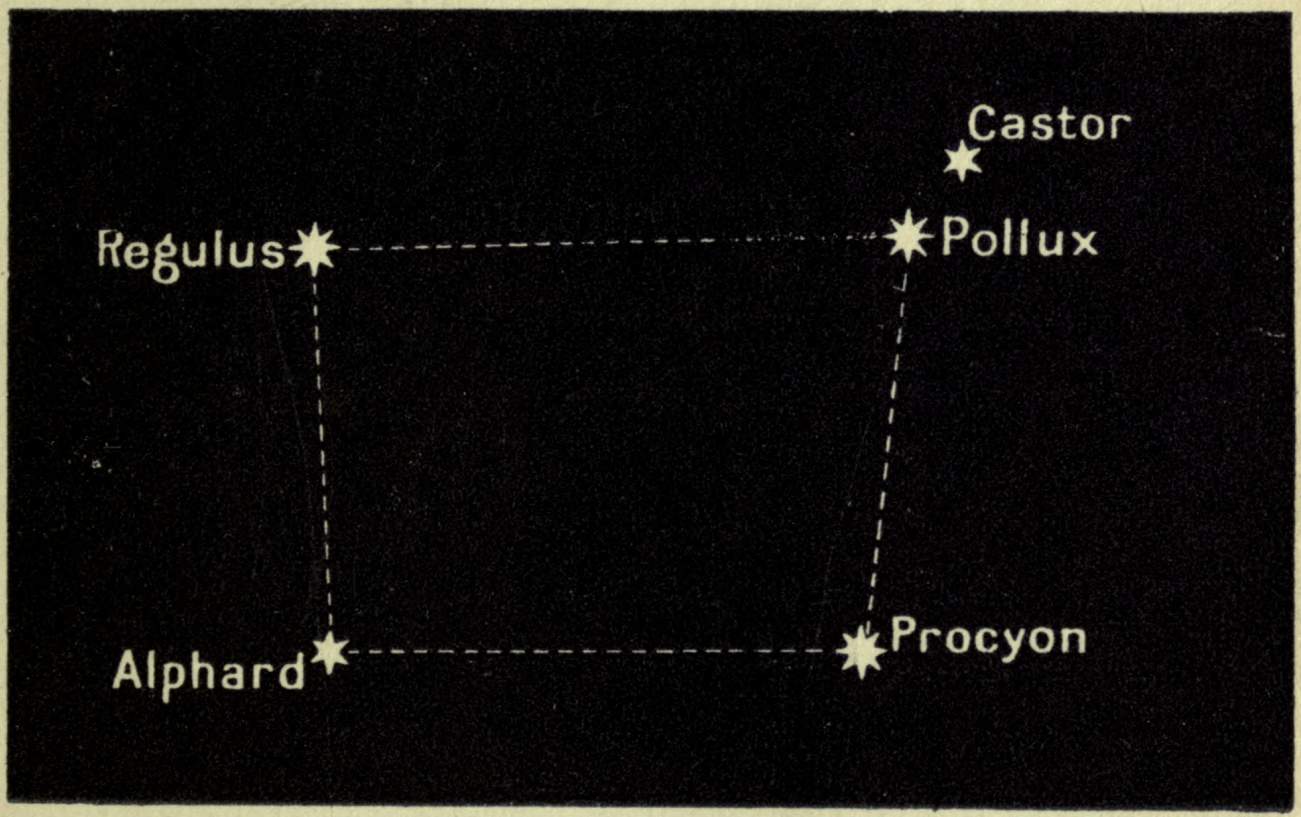
PLAN 9


Capella
AURIGAE
β
Aldebaran
Castor
Pollux
Bellatrix
γ
Betelguese
α
ORION
δ
ε
ζ
Rigel
β
Procyon
Alphard
Sirius
CANIS
MAJORIS
β

10. Alphard

Alphard, a lonely star of no great importance, forms a rectangle with Regulus, Pollux, and Procyon, as in the figure.

PLAN 10

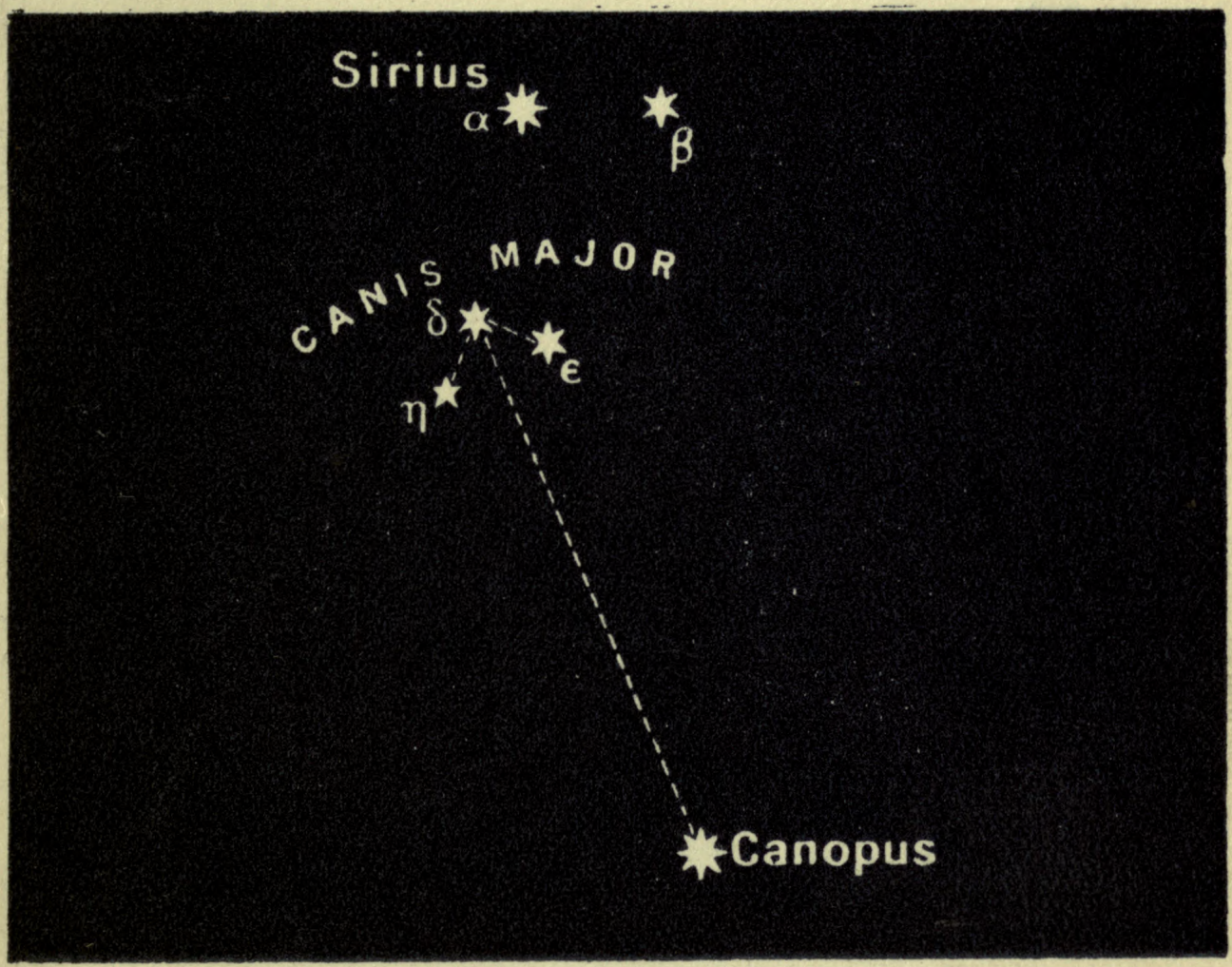


11. Canopus

Canopus is so bright that it is not likely to be mistaken among the many fairly good stars near it.

It is best found by bisecting the right-angle formed by three good stars in CANIS MAJOR south of Sirius, as in the figure.

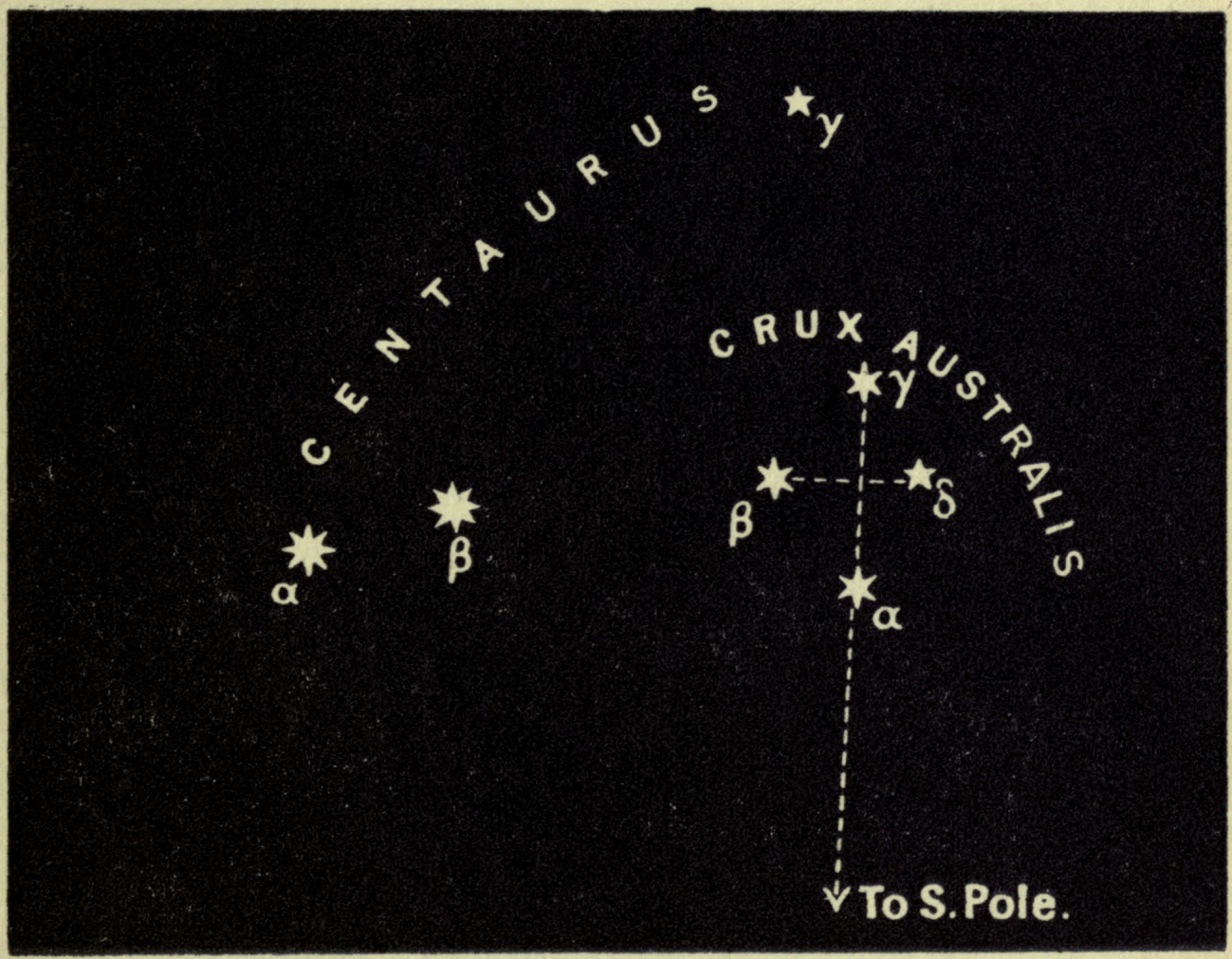
PLAN 11



12. The Southern Cross and the Centaur

The striking form of the Cross makes it easily identified when seen nearly vertical and at a fair height. At other times the "cross" form is much less noticeable, and it is sometimes confused with four stars in ARGO. But the two very bright stars α, β CENTAURI, not far away, point to the Cross and mark it clearly.

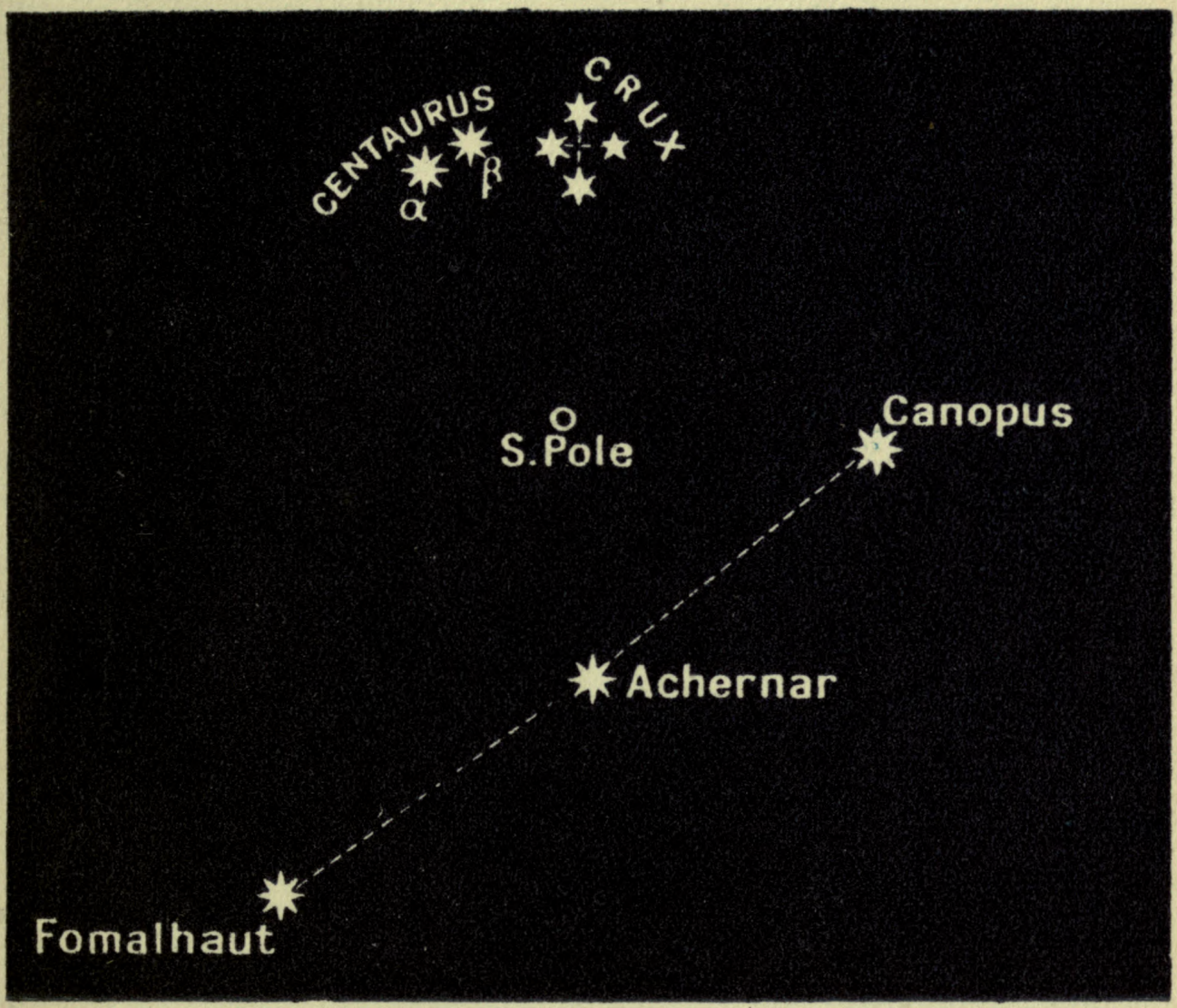
PLAN 12



13. Achernar

The bright lonely star Achernar lies at the same distance from the South Pole as β CENTAURI and just opposite to it. It is just midway between Canopus and Fomalhaut.

PLAN 13



14. Stars of the North Hemisphere

This plan is to give a general idea of the relative positions of all the Northern stars. A few Southern stars are included for convenience.

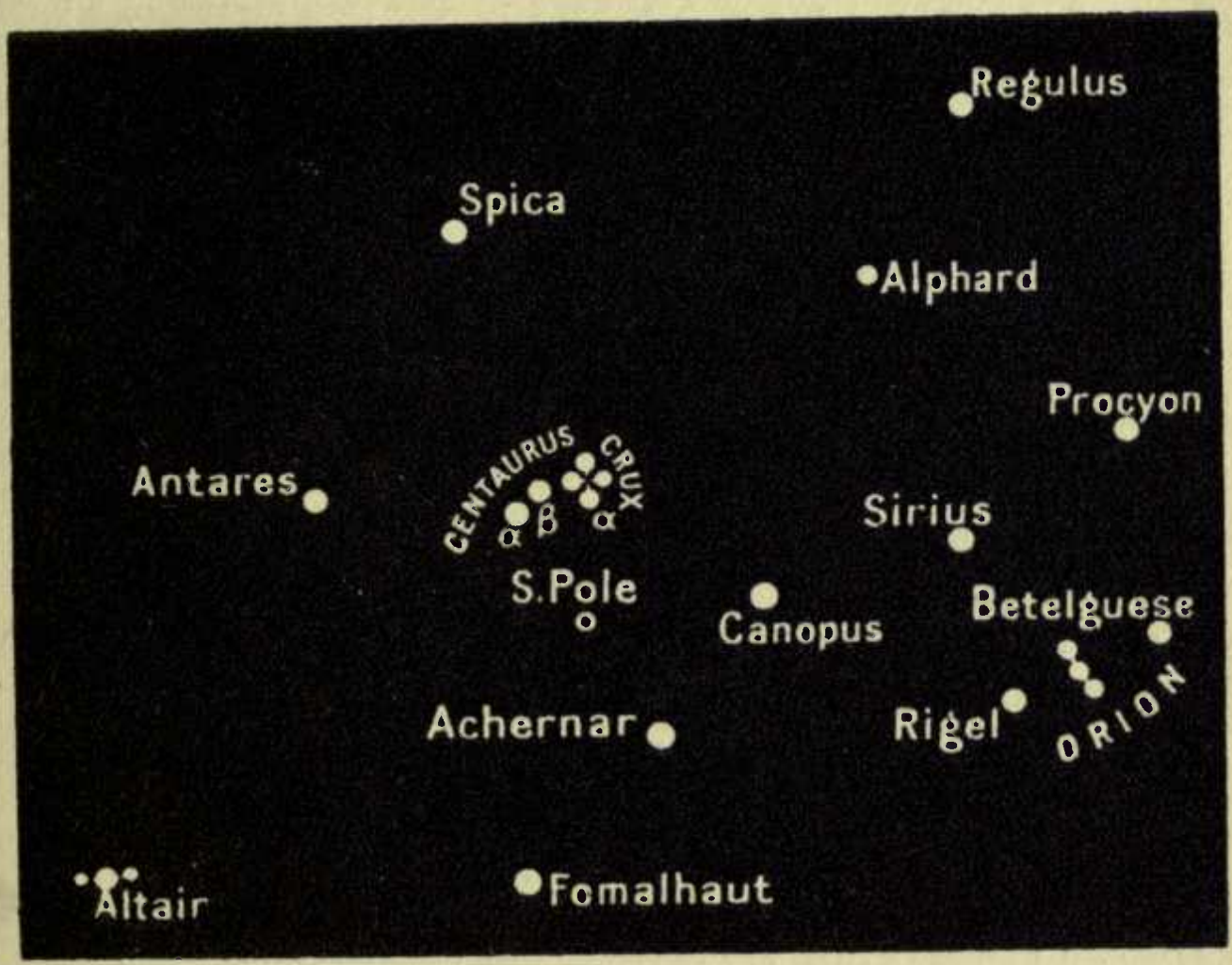
PLAN 14


PEGASUS
ANDROMEDA
Aldebaran
Rigel
CASSIOPEIA
PERSEUS
ORION
Altair
CYGNUS
Deneb
Sirius
Betelguese
Capella
Vega
Polaris
Castor
Procyon
Pollux
URSA MAJOR
Regulus
Arcturus
Denebola
Alphard
Spica

15. Stars of the South Hemisphere

This plan is to give a general idea of the relative positions of all the Southern stars. A few Northern stars are included for convenience.

PLAN 15


Regulus
Spica
Alphard
Procyon
Antares
CENTAURUS
CRUX
α
β
α
Sirius
S.Pole
Canopus
Betelguese
Achernar
Rigel
ORION
Altair
Fomalhaut

PROBLEM

Assuming that we now have the means of identifying any of the stars shown in the plans, we can proceed to our problem of determining the N. and S. line.

This may be done in three ways:—

I. By marking the position of a pole.

II. By noting the transit of a known star.

III. By means of what we may call "simul-transit" stars.

I

(A) The North Pole is conveniently marked with fair accuracy by a star, Polaris.

Its position may be found by means of various markers.

(1) As is generally known, the markers β, α of the Great Bear point directly to the Pole Star. (Star Plan 1.)

(2) A line bisecting the angle between $\alpha\beta$, $\alpha\gamma$ of CASSIOPEIA points almost directly to Polaris, the distance being about the same as in (1). (Star Plan 7.)

(3) An equilateral triangle erected with base

the line joining Arcturus and Regulus (on the right), will have Polaris near its vertex.

(4) An equilateral triangle erected with base the line joining Vega and Arcturus (on the right), will have Polaris near its vertex.

(5) The special problem dealt with in III. will introduce some good new direction lines for Polaris.

(B) There is no bright star near the South Pole.

(1) To find the South Pole produce the long side $\gamma\alpha$ of the Southern Cross four and a half times its own length. When this side of the Cross is vertical it bears due south.

(2) The special problem dealt with in III. will introduce some new direction lines for the South Pole.

II. By noting the transit of a known star

A.—Explanatory

Consider for a moment the motion of the heavens as seen from the earth. The earth being regarded as fixed, the heavens revolve about an axis formed by the axis of the earth

produced both ways through the poles, the stars being points of light fixed on this spherical globe of the heavens. Clearly then to an observer at the North Pole every star he sees will describe a circle parallel to the plane of the equator, neither rising nor setting, but always at the same altitude: the Northern Hemisphere stars he will always see, the Southern never. But as he moves away from the Pole things change: the stars still describe the same circles or rings round the Pole, but the plane of his horizon is not now parallel to the equator; the N. star is not right overhead, and any star revolving round it is seen sometimes below it, sometimes above. While the observer is still in a high N. latitude the Pole will still be high in the sky, and the stars not very far from it will make their whole daily circle above the plane of the horizon. But stars further from the Pole will only be above the horizon for part of their course, and naturally can only be seen then; that is, they rise, ascend gradually in a circular arc to a certain vertical height or altitude, descend gradually down the same circular arc continued, and set.

On the other hand stars of the Southern Hemi-

sphere, but not too far from the equator, will now be visible for a short time and to a small altitude. As an observer travels south these stars rise higher, the North Pole star is seen less and less high, and gradually a different set of stars replace the original ones. Of course about the equator most stars of both N. and S. can be seen: thus it is possible to see the Pole Star and the Southern Cross at the same time and place.

Clearly then: *whether a star is ever visible at a place or not is a question of latitude;* and so, too, how high up in the sky it rises, and for how long it is visible: for example, the same stars are seen any night at (say) 10 P.M. in Malta and Tokio.

On the other hand: *when a star is visible at a place is a question of the season of the year;* understanding by "when" what time of day or night.

For the complete revolution of the earth on its axis does not take just 24 hours (as we measure time, by the sun). It is very near it, but not quite. If it did, the same stars would be visible at a place at the same time night after night; and some stars though they rose well above our horizon we might never see at all, as they would always rise and set during the daytime, when the

light of the sun blots out the stars. But, owing to the sun's own motion, the revolution of the earth on its axis takes about 4 minutes less than our day of 24 hours, and, as a result, every star rises 4 minutes earlier each successive day, and so also reaches its highest point 4 minutes earlier and sets 4 minutes earlier. This small daily change works out at 2 hours a month, or 24 hours a year very nearly. Thus the stars are seen in the same places at the same time of day in any latitude every January 1st, every June 1st, and so on; and a star that we see in the summer nights this year we shall see in the summer nights next year and the year after, but in the winter nights we shall see another set of stars, those that are up during the summer days. Of course, stars that never set in certain high latitudes are seen there summer and winter alike; thus the Great Bear is visible to the British Isles all the year round.

Now imagine a circle drawn through the celestial Poles and the point of the heavens vertically above the observer's head. This point is known as the *Zenith*, and the circle on the celestial sphere as the *Meridian* of the observer. This circle, obviously, meets the horizon in the N. and

S. points. Now since any visible star is describing a circle about the visible Pole it is always the same distance from that Pole. Thus we see at once that it reaches its greatest altitude in the sky when vertically above the Pole; that is, when on this circle we call the Meridian; that is, when it bears N. or S.

A star is said to *Transit* when it crosses the Meridian. Therefore, *at Transit a star reaches its greatest altitude in the sky, and also it then bears due N. or S.*

It is of this coincidence that we now make use. For if we can determine the time a known star is going to transit and then at that time we look at this star we must clearly be then looking due N. or due S.

TABLE X.—A table has therefore been made out showing at what day in the year all the chief stars transit at midnight (that is, when they are longest visible).

Looking at this table and using the 4 minutes earlier every night rule explained above and given in the table, we can easily work out what time any bright star given there will transit on any night we like. When a watch, which must be

keeping correct local time, shows this moment the star will then show us N. or S.

TABLE Y.—But which? Some stars transit to the N., some to the S., a matter clearly depending on (1) the distance of the star from the Pole; (2) the latitude of the observer. To show this, and to ensure that we are not trusting to stars which never rise at all in our latitude, another table, Y, has been made out. This shows the greatest altitudes (*i.e.* at transit) attained by all the chief stars in certain chosen latitudes, and whether they point N. or S. It will be seen that it is quite easy to work it out for any other latitude.

These two tables (X and Y) enable us to foretell at once what stars to look for anywhere (Table Y), and anywhen (Table X).

TABLE W.—Another table is added showing the interval of time for certain stars between star-rise and transit, or transit and star-set in various latitudes. This will help us still further to tell what stars will be visible any night.

B.—Practical Rule

All the above explanations have been given because it is much better that one should under-

stand something of the motion of the heavens, and why and where we see the stars. But to use the tables it is not necessary to understand this. We can simply follow this rule:—

Find by Table X what time the star (or stars) we wish to use transits. At this time by your watch look at the star. It will point due N. or S., as given by Table Y, and will be at the altitude found there.

C.—Examples

1. Suppose you are to make a night march in North Nigeria in the beginning of May, say May 5th.

Lokoja is about the same latitude as Trincomalee.

From Tables X and W we see at once that suitable stars for the time of year are α, β CRUCIS, Spica, β, α CENTAURI, Arcturus, Antares, and Vega.

From Table Y we see that all these stars are visible there, though Arcturus and Spica transit rather high to give us a very good N. S. line, and the stars of CRUX and CENTAURUS may be found too low down.

We proceed to reason as follows: Spica transits at midnight on April 12th, therefore on May 5th it will transit about (4 minutes × 23 days equals 92 minutes) 1 hour 32 minutes earlier; that is, about 10.28 P.M.

Vega transits at midnight on July 1st, therefore on May 1st it will transit (2 hours × 2 months) equals 4 hours *later*, and on the 5th 16 minutes earlier again than this, *i.e.* at about 3.44 A.M.

In exactly the same way we can place the transits of the other stars, and prepare a column of results as follows:—

α CRUCIS	will bear due	S.	at an altitude of	18°	at about	9.32 P.M.
β CRUCIS	,,	S.	,,	21°	,,	9.52 P.M.
Spica	,,	S.	,,	70°	,,	10.28 P.M.
β CENTAURI	,,	S.	,,	21°	,,	11.8 P.M.
Arcturus	,,	N.	,,	79°	,,	11.20 P.M.
α CENTAURI	,,	S.	,,	21°	,,	11.44 P.M.
Antares	,,	S.	,,	55°	,,	1.36 A.M.
Vega	,,	N.	,,	60°	,,	3.44 A.M.

Thus between the hours of 9.30 P.M. and 4 A.M. we may get, with the help of a star pocket-book and a watch alone, as many as eight precise bearings of N. and S. in a latitude where the Pole Star will hardly be seen, and both the Great Bear and the Southern Cross set early (at this date). The sun in this case sets at 6.10 P.M. and rises

again at 5.50 A.M., so if more markers yet were required we could take Dubhe, transiting N. about 8 P.M. at 39°; but Denebola (8.50 P.M.) and Altair (5 A.M.) both transit too much overhead for our purpose.

2. To make a night march in the neighbourhood of Pretoria on the night of December 19th.

Proceeding as before we easily work out that

α PERSEI	will bear	due	N.	at an altitude of	16°	at about 9.29 P.M.
Aldebaran	,,		N.	,,	48°	,, 10.40 P.M.
Capella	,,		N.	,,	18°	,, 11.20 P.M.
Rigel	,,		N.	,,	72°	,, 11.20 P.M.
Bellatrix	,,		N.	,,	58°	,, 11.32 P.M.
Betelguese	,,		N.	,,	57°	,, Midnight
Canopus	,,		S.	,,	63°	,, 12.32 A.M.
Sirius	,,		N.	,,	80°	,, 12.52 A.M.
Procyon	,,		N.	,,	59°	,, 1.44 A.M.
Pollux	,,		N.	,,	36°	,, 1.48 A.M.
Alphard	,,		N.	,,	72°	,, 3.32 A.M.
Regulus	,,		N.	,,	52°	,, 4.12 A.M.

Thus we have a long succession of bright stars, well visible, to choose from; on a fine night with watch and pocket-book it would hardly be possible to go far wrong, though the Pole Star, Bear, and CASSIOPEIA are all invisible, and the Southern Cross does not rise much before midnight.

III. By Simul-transit Stars

A.—Explanatory

We have now seen how, lacking the means of obtaining the Poles directly, the star pocket-book and a watch are all we need to obtain a number of accurate pointers during a fine night; more or fewer, according to circumstances, but always some. But the pocket-book and watch are still necessary. What can we do without them?

Here, what I have called simul-transit stars occurred to me. Every star, we have seen, transits due N. or S. If then we can find two bright stars which transit at the same time they must be both on the Meridian at the same time; that is, they must then be in the same vertical plane. So that if we know two stars to be a simul-transit pair when we observe them to lie in the same vertical plane we can say at once, "Those stars are transiting, therefore they bear due N. (or S., according to which is higher)." Hence the direction line is at once obtained. To do this best neither star should be too high in the sky, but they should be a fair distance apart to determine the transit line

nicely. Of course in some cases they will lie one each side of the Zenith.

Are there, then, many pairs of these simul-transit stars? This is not, I may note, a point that interests the navigator; he wants to get two stars bearing far apart at any moment. Nor, perhaps, are these transits sufficiently close together to be of importance in the accurate observations of the astronomer. But it is clear they may be of great help in the rough calculations of the night-marcher.

The next thing, therefore, was to find out how many of these pairs of stars there were, and to tabulate them.

TABLE Z.—The result exceeded expectations: there are quite a reasonable number of easily-known stars which transit together or within a few minutes of each other. Table Z shows a list of these, and that they are fairly scattered over the heavens. There was a bad break of 10 hours (in time of transit) in my first list between the times for β CENTAURI and for Fomalhaut, but by introducing the smaller stars of CYGNUS, which are not very hard to distinguish, this is considerably reduced. It has been necessary to make use,

too, of the stars of CASSIOPEIA, ANDROMEDA, and the Great Bear, but none of these are difficult to learn, and they admit of very constant practice in the latitudes of Europe. On the other hand, there is this against constellations so near the North Pole as these, that if we can see their stars at all we are likely to see Polaris itself and so save all this trouble. Quite the most remarkable case is that of Capella and Rigel, two splendid stars at a good distance apart and at good distances from the Poles, and visible over a large range of likely latitudes. Pollux and Procyon form another fine pair of transit-twins, and the triplets, β and α PEGASI with Fomalhaut, are also good.

B.—Practical Rule

Watch a pair of simul-transit stars as learnt or found from Table Z. When you judge them to be in the same vertical plane—

(1) if on the same side of the Zenith they will point N. or S. according to circumstances; the observer should be able to discriminate easily from the positions of other stars near them.

(2) if one each side of the Zenith the star known to be nearer the North Pole will point north.

C.—Examples

1. Suppose a unit or detachment to be marching by night in the Malay States near Kwala Lumpur (about 3° N.) on October 8th. Here there is little chance of seeing the North Star, and the Great Bear and Southern Cross are only much above the horizon during daylight. Referring, *merely for convenience*, to Table X and Table Y to determine the times and heights of transit of the simul-transit stars given in Table Z, we find that in fact we shall get the following events.

At about

7.30 P.M. Deneb and ϵ CYGNI will be in a vertical line due N.

9.45 P.M. Markab and β PEGASI will be in a vertical line due N., with Fomalhaut also on the same vertical circle but pointing S.

11.0 P.M. α ANDROMEDAE and β CASSIOPEIAE will be in a vertical line due N.

12.0 P.M. β ANDROMEDAE and γ CASSIOPEIAE will be in a vertical line due N.

12.30 A.M. Achernar (to S.) and δ CASSIOPEIAE (to N.) will be on the same vertical circle.

At about

1.0 A.M. α ARIETIS, γ ANDROMEDAE, and ϵ CASSIOPEIAE will be in a vertical line due N.

4.0 A.M. Capella (to N.) and Rigel (to S.) will be on the same vertical circle.

4.40 A.M. β AURIGAE (to N.) and Betelguese (in the Zenith, and therefore useless) will be in a vertical line

5.15 A.M. β CANIS MAJORIS and Canopus will be in a vertical line due S.

Thus an observer who knew the simul-transit stars, simply by watching these come into a vertical line, could place the N. point about eight times during the night.

2. For a night march near Durban (lat. 30° S.) on March 23rd.

Here of all the useful stars in the Great Bear only η is likely to be high enough to be of service. We therefore tabulate only these results.

At about

7.30 P.M. Procyon and Pollux will be in a vertical line due N.

12.25 A.M. α CRUCIS and γ CRUCIS will be in a vertical line due S.

12.45 A.M. β CRUCIS and γ CENTAURI will be in a vertical line due S.

2 A.M. β CENTAURI (to S.) and η URSAE MAJORIS (to N.) will be in the same vertical circle.

We note that the Southern Cross will be visible all night, so we can always get near the South Pole by means of it; but the other checks are useful. The Pollux-Procyon line, in particular, lying far away from the Cross, might be of the utmost service on a cloudy evening.

D.—Simul-transit Stars as Pole Pointers

But the use of simul-transit stars is by no means confined to the moment that they transit; they are of very great service also as pointers to the Pole.

For it is obvious that our usual simple pairs of Pole pointers, namely, β, α URSAE MAJORIS for North Pole, and γ, α CRUCIS for South Pole, are merely convenient pairs of simul-transit stars; since, to point at the Pole, when one transits the other must do so too. Conversely, it is clear that any pair of simul-transit stars, since they cross the

meridian together, lie on the same great circle through the Poles, and therefore afford us pointers to the Pole as well, and can be used simply as such.

These are the additional direction lines promised in I. A. (5), and I. B. (2).

An observer, then, who knows the simul-transit stars is often independent of other aid. He can choose two pairs of these, and following the line of the great circle through each pair he places the N. (or S.) point where these great circles intersect; and this he can do at any moment he likes.

If, in addition, he remembers some of the simple relative distances between stars and Pole as given in Table Z, he can locate the Pole with fair accuracy by one pair of simul-transit stars alone. Thus in Example II., C. (1), suppose breaks in a cloudy sky about 2 A.M. gave him momentary glimpses of Capella and Rigel, two fine stars and quickly recognised. His eye at once sweeps out the arc from Rigel to Capella, and, following it down through a distance roughly equal he fixes, low down in a dark sky, the invisible Pole Star.

The best pairs of these simul-transit stars for

all considerations are marked in Table Z, but it is worth remarking that for snap-shot work in cloudy weather the stars of CASSIOPEIAE and ANDROMEDA are extremely good. These constellations lying not very far apart, it is very probable that when one can be seen the other can also; in each case it is an equal distance from star to star and star to Pole; and as this distance is not very great the North Pole is obtained with the nicest accuracy.

Summary

The star pocket-book is now complete. Its aim, to recapitulate, has been throughout to enable a traveller by starlight on land to obtain such assistance on his way as he may be able to get from a knowledge of the direction line N. and S. And this is to be found simply, without any complicated mathematical calculations or dependence on varying and recondite data.

For this purpose a practical acquaintance with the stars is essential, and so plans are first given for learning such of these as seem to be requisite.

The actual problem of determining the N.

and S. line has then been dealt with in three ways.

I. By marking a Pole.
II. By the transit of a known star.
III. By simul-transit stars or Pole-pointers.

Of these we may say the first is clearly the simplest and best, and should be employed wherever possible. The second is rather complicated, as it requires a little calculation and the use of a correct watch and the pocket-book. It has affinities with the problem of "marching on a star"; it is often quite as good as this, and has the great advantage that the necessary calculations are much more easily got at and worked out. And it need hardly be pointed out that the Tables given for use of this method (Tables X, Y, W) will also be of service in helping one to learn the stars, to become generally conversant with the nature of the visible heavens at any time and place, and to gather such indications of direction as may be by noting stars which one knows to be rising; that is, in the E.: or setting; that is, in the W.

For the third method, the simul-transit pairs of stars have been used in two ways. The first,

noting where they are in vertical line, or perhaps estimating where they will be, or have been, in vertical line, may sometimes be found a good substitute for I. More valuable still, and practically the same as I., is their use as Pole-pointers, and some pairs of these stars at least should be known and remembered. It is their use in bad weather that gives their great importance; they may serve where nothing else can. For instance, an observer was able one stormy summer night on Exmoor to fix the N. with perfect accuracy (as he found half-an-hour later when Polaris cleared) from a momentary glimpse during heavy rain of Altair and δ CYGNI.

To conclude, it should be quite possible with regular practice and some study of the pocket-book for any one to attain something of that extraordinary gift for finding their way by the stars which we credit to backwoodsmen, trappers, and Indians; at the least a night-marcher furnished with this pocket-book, or information gathered from it, would prove a more useful guide than one who knew nothing of the stars.

TABLE X.—Time of Year when certain Stars Transit at Midnight.

Date.	Star.	Date.	Star.
Jan. 1	Sirius	July 1	Vega
,, 13	Castor	,, 19	Altair
,, 15	Procyon	Aug. 2	Deneb
,, 16	Pollux	Sept. 5	Fomalhaut
Feb. 11	α HYDRAE	,, 7	α PEGASI
,, 21	Regulus	,, 23	α ANDROMEDAE
Mar. 7	α URSAE MAJORIS	Oct. 8	β ANDROMEDAE
,, 19	Denebola	,, 15	Achernar
,, 29	α CRUCIS	,, 22	Hamel
Apr. 3	β CRUCIS	Nov. 11	α PERSEI
,, 12	Spica	,, 29	Aldebaran
,, 22	β CENTAURI	Dec. 9	Capella
,, 25	Arcturus	,, 9	Rigel
May 1	α CENTAURI	,, 12	Bellatrix
,, 29	Antares	,, 19	Betelguese
June	... ...	,, 27	Canopus

Rule to find the Time of Transit of a Star on any Night

Each star transits very nearly 4 minutes (3 minutes 56 seconds) earlier each successive night, or about 2 hours earlier each successive month.

Note.—The times so obtained may be a few minutes out, because (1) the times of transit vary slightly in different years; (2) 2 hours a month is not absolutely correct for all months. But these errors are negligible, as a star changes its bearing very slowly when near its transit.

TABLE W.—Time between Transit and Rising or Setting of Stars in Various Latitudes.

Name of Star.	Aberdeen 57° N.	London 52° N.	Malta 36° N.	Bombay 19° N.	Trincomalee 9° N.	Mombasa 3° S.	Pretoria 26° S.	Cape Town 34° N.	Wellington 41° S.
	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.
α URSAE MAJORIS	..	..	..	8·7	7·1	5·6	1·2	..	..
β ,, ,,	..	..	..	8·1	6·9	5·6	2·7	..	..
Capella	..	..	9·3	7·4	6·6	5·7	4·0	3·0	1·7
Vega	..	..	8·4	7·1	6·5	5·8	4·4	3·8	3·0
Pollux	9·7	8·9	7·5	6·7	6·3	5·8	5·0	4·6	4·2
Arcturus	8·3	7·9	7·0	6·5	6·2	5·9	5·3	5·0	4·8
Regulus	7·3	7·1	6·6	6·3	6·1	5·9	5·6	5·4	5·3
Betelguese	6·7	6·6	6·3	6·2	6·1	6·0	5·8	5·7	5·6
Rigel	5·2	5·3	5·6	5·8	5·9	6·0	6·3	6·4	6·5
Spica	4·9	5·0	5·4	5·7	5·9	6·0	6·4	6·5	6·6
Sirius	4·2	4·5	5·2	5·6	5·8	6·1	6·6	6·8	7·0
Antares	2·7	3·4	4·6	5·4	5·7	6·1	6·9	7·3	7·7
Fomalhaut	..	2·8	4·3	5·2	5·6	6·2	7·1	7·5	8·0
Canopus	..	..	..	4·3	5·3	6·3	8·6	10·1	..
γ CRUCIS	..	..	..	3·9	5·1	6·3	9·3	..	..
α ,,	..	..	..	3·3	4·9	6·4	10·4	..	..

Note.—A blank mark signifies: BLUE, that the star never sets; RED, that the star never rises.

With these values given we can easily interpolate to find the time for any other star with sufficient accuracy by the help of Table Y.

It will be noted that a star lying north of the celestial equator is always visible for more than 12 hours at a place in north latitude and less than 12 hours in south latitude, and *vice versâ* for south stars.

TABLE Y.—Highest Altitude of Stars in Various Latitudes.

Name of Star.	Star's Declination.	London 52° N.	Malta 36° N.	Bombay 19° N.	Trincomalee 9° N.	Mombasa 3° S.	Pretoria 26° S.	Cape Town 34° S.	Wellington 41° S.
	N.								
ε CASSIOPEIAE	63°	79° 25°	63° 10°	46°	36°	24°	Horizon	..	..
α URSAE MAJORIS	62°	80° 24°	64° 9°	47°	37°	25°	Horizon	..	..
γ CASSIOPEIAE	60°	82° 22°	66° 7°	49°	39°	27°	Horizon	..	..
δ ,,									
β CASSIOPEIAE	58·5°	83° 21°	67° 6°	50°	40°	28°	Horizon	..	..
β URSAE MAJORIS	57°	85° 19°	69°	52°	42°	30°	7°	..	..
δ ,, ,,									
α CASSIOPEIAE	56°	Zenith 18°	70°	53°	43°	31°	8°	Horizon	..
γ URSAE MAJORIS	54°	Zenith 16°	72°	55°	45°	33°	10°	Horizon	..
η URSAE MAJORIS	50°	Zenith 12°	76°	59°	49°	37°	14°	6°	Horizon
α PERSEI									
Capella	46°	84° 8°	80°	63°	53°	41°	18°	10°	Horizon
Deneb									
δ CYGNI	45°	83° 7°	81°	64°	54°	42°	19°	11°	Horizon
β AURIGAE									
γ ANDROMEDAE	42°	80°	84°	67°	57°	45°	22°	14°	7°
Vega	39°	77°	Zenith	70°	60°	48°	25°	17°	10°
β ANDROMEDAE	35°	73°	Zenith	74°	64°	52°	29°	21°	14°
ε CYGNI									
α ANDROMEDAE	28·5°	67°	83°	80°	70°	58°	35°	27°	20°
Pollux	28°	66°	82°	81°	71°	59°	36°	28°	21°
β PEGASI									
Hamel	23°	61°	77°	Zenith	76°	64°	41°	33°	26°
Arcturus	19·5°	58°	74°	Zenith	79°	67°	44°	36°	29°
Aldebaran	16°	54°	70°	Zenith	83°	71°	48°	40°	33°
Denebola	15°	53°	69°	Zenith	84°	72°	49°	41°	34°
α PEGASI									

TABLE Y.—(*Continued.*)

Name of Star.	Star's Declination.	London 52° N.	Malta 36° N.	Bombay 19° N.	Trincomalee 9° N.	Mombasa 3° S.	Pretoria 26° S.	Cape Town 34° S.	Wellington 41° S.
	N.								
Regulus	12·5°	50°	66°	83°	Zenith	75°	52°	44°	37°
Altair	8·5°	46°	62°	79°	Zenith	79°	56°	48°	41°
Betelguese	7·5°	45°	61°	78°	Zenith	80°	57°	49°	42°
Bellatrix	6°	44°	60°	77°	Zenith	81°	58°	50°	43°
Procyon	5·5°	43°	59°	76°	Zenith	82°	59°	51°	44°
	S.								
Rigel / Alphard	8°	30°	46°	63°	73°	85°	72°	64°	57°
Spica	11°	27°	43°	60°	70°	82°	75°	67°	60°
Sirius	16·5°	21°	37°	54°	64°	76°	81°	73°	66°
β CANIS MAJORIS	18°	20°	36°	53°	63°	75°	82°	74°	67°
Antares	26°	12°	28°	45°	55°	67°	Zenith	82°	75°
Fomalhaut	30°	8°	24°	41°	51°	63°	86°	Zenith	79°
γ CENTAURI	48·5°	..	Horizon	22°	32°	44°	67°	75°	82°
Canopus	52·5°	..	Horizon	18°	28°	40°	63°	71°	78° 4°
γ CRUCIS	56·5°	..	..	14°	24°	36°	59°	67°	74° 8°
Achernar	57·5°	..	..	13°	23°	35°	58°	66°	73° 9°
α CENTAURI / β ,, / β CRUCIS	60°	..	..	11°	21°	33°	56°	64° 4°	71° 11°
α CRUCIS	62·5°	..	..	8°	18°	30°	53°	61° 7°	68° 14°

Stars above the black line lie North of the celestial equator. Stars below the black line lie South of the celestial equator.

RULE.—Face North for stars marked in blue; face South for stars marked in RED.

Note.—Where two altitudes are given for a star at any place it is always above the horizon there and the second altitude given is its least at its lower transit 12 hours after its upper transit.

TABLE Z.—Simul-transit Stars.

To North Pole.	Comparative distances from 1st Star to 2nd, and 2nd to Pole.
* Procyon and Pollux	2 : 5
*β URSAE MAJORIS and α URSAE MAJORIS	1 : 5
Denebola and γ URSAE MAJORIS	10 : 9 †
Spica and ζ URSAE MAJORIS	9 : 7
β CENTAURI and η URSAE MAJORIS	7 : 2
* Altair and δ CYGNI	4 : 5 †
ϵ CYGNI and Deneb	1 : 4
* Fomalhaut and α PEGASI and β PEGASI	3·5 : 1 : 5
α ANDROMEDAE and β CASSIOPEIAE	1 : 1
β ANDROMEDAE and γ CASSIOPEIAE	5 : 6 †
Acherner and δ CASSIOPEIAE	4 : 1
Hamel and γ ANDROMEDAE and ϵ CASSIOPEIAE	6 : 7 : 9 †
* Rigel and Capella	4 : 5 †
Betelguese and β AURIGAE	4 : 5 †
To South Pole.	
*γ CRUCIS and α CRUCIS	1 : 4·5
γ CENTAURI and β CRUCIS	1 : 3
*β CANIS MAJORIS and Canopus	1 : 1

Note.—The star farther away from the Pole referred to is given first.
* Signifies the most important pairs of stars.
† In these cases the distances for practical measurement with the naked eye may be taken as 1 : 1.

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